Fisheries and Oceans Canada | Pêches et Océans Canada
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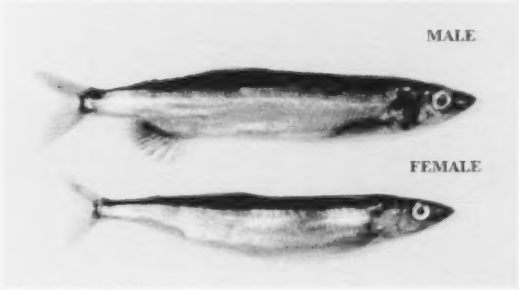
Quebec Region
Canadian Science Advisory Secretariat
Science Advisory Report 2013/021

ASSESSMENT OF THE ESTUARY AND GULF OF ST. LAWRENCE (DIVISIONS 4RST) CAPELIN STOCK



(Source : DFO)

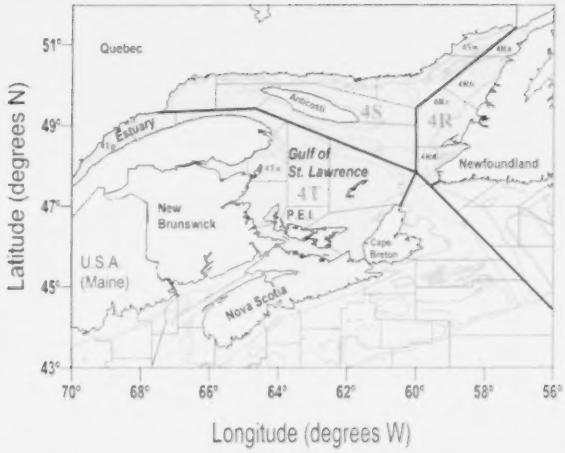


Figure 1. Map of NAFO Divisions 4RST (Estuary and Gulf of St. Lawrence). Divisions 4RST are identified by the coloured area.

Context

In the Estuary and Gulf of St. Lawrence, capelin has traditionally been used as fertilizer, bait or for its oil. Towards the end of the 1970s, the emergence of a Japanese market for roe-bearing females sparked a rapid growth of the fishery with catches that increased from approximately 700 t per year to more than 10,000 t. In NAFO Divisions 4RST, most capelin catches are made on the west coast of Newfoundland by a fleet of small and large purse seiners and by "Tuck ring" seines and trap fishermen. Capelin are also caught using traps on Quebec's Lower North Shore and weirs in the St. Lawrence Estuary. In addition to recreational catches made on beaches during the spawning season, capelin are also a by-catch of the shrimpers and the multidisciplinary groundfish and shrimp (Pandalus borealis) surveys conducted annually by DFO in the Estuary and northern and southern Gulf of St. Lawrence.

Even though capelin population structures in the Estuary and Gulf of St. Lawrence are not clearly defined, the species is managed as a single stock according to two distinct management units, NAFO (Northwest Atlantic Fisheries Organization) Divisions 4R and 4ST (Figure 1). A Total Allowable Catch (TAC) of 13,000 t is applied to all of the stock. This TAC is divided as follows: 11,195 t for Division 4R and 1,805 t for all of Divisions 4ST. There is no abundance survey specifically directed on capelin. Consequently, it is impossible to calculate spawning biomass, fishing mortality and reference points, which would help define, based on the precautionary approach, a decisional framework for the fishery and a TAC.

The last capelin assessment in Divisions 4RST was conducted in 2010. The Fisheries and Aquaculture Management Branch requested science advice on this stock for the 2013 and 2014 fishing seasons. This document should meet, at least in part, their request as it provides a status update for this resource based on the information currently available.

Canada

SUMMARY

- Since 2008, the average capelin landings in NAFO Divisions 4RST are 11,429 t per year. From 12,314 t in 2011, they decreased to 9,472 t in 2012. Most of these landings are from a seine fishery that is conducted on the West coast of Newfoundland (Division 4R).
- The decrease in landings recorded in 2012 was particularly marked in unit areas 4Sw (Quebec Lower North Shore) and 4Tn (Miscou Bank). In 4Sw, this decrease could be explained by a spawning that occurred in deeper waters and outside the trap fishery area. In 4Tn, the spawning would have occurred before the regular activities of the seine fishery.
- An index measuring the performance of the seiner's fishery in Division 4R is on the rise since 2005 so that the recent values of this index are the highest of the series.
- Capelin is a regular by-catch of the shrimp fishery. Based on observer data (5% coverage), 149 t of capelin would have been caught and discarded in 2012, for most in the Seven Islands shrimp fishery area. Since 2000, these by-catches have varied from 77 t to 322 t. These catches are not recorded in the official statistics of the Department.
- On the west coast of Newfoundland, the length of capelin caught by seine declined in the early 1990s until 2001. It increased thereafter and the lengths measured since 2005 have been near the historical averages. The length of capelin from the east coast of Newfoundland has declined more significantly, and since the mid-1990s, has been similar to that of the Gulf.
- Since 1990, the presence of capelin in the bottom trawl multidisciplinary surveys has become more widespread in the southern Gulf of St. Lawrence (Division 4T). This increase could be explained by an increased presence of capelin near the bottom and/or by a change in abundance and/or dispersion.
- An index measuring the dispersion (and not the abundance) of capelin during the multidisciplinary bottom trawl surveys in the Gulf of St. Lawrence (North and South) presents a clear trend on the rise since 1990. Values measured since 2010 are the highest in the series.
- Due to the capelin's prominent role as a forage species in the marine ecosystem, any increase in the 4RST TAC should be made cautiously, less than 10% as a total over the next two years. The fishing effort should be more dispersed along the coast and less concentrated locally.

INTRODUCTION

Species Biology

Capelin (*Mallotus villosus*) is a small marine fish species largely distributed in the oceans of the northern hemisphere. In the northeast Atlantic, capelin occur in waters near Russia (Barents Sea), Norway, Iceland, and Greenland. In the northwest Atlantic, it is found along the coasts of Labrador and Newfoundland, on the Grand Banks and in the Estuary and Gulf of St. Lawrence. Further south, capelin are also found in the eastern portion of the Scotian Shelf and occasionally, in the Bay of Fundy. In the Pacific, the species occurs along the coasts of Alaska and British Columbia, and in Asia, along the coasts of Japan, Korea, and Russia.

Capelin, part of the Osmeridae family, are olive in colour and have an elongated body. During the spawning period, there is a pronounced sexual dimorphism, males can be distinguished

from females by their larger fins and by the occurrence of two pairs of spawning carina (elongated scales), one dorsal and the other ventral. Spawning is preceded by intense migration towards the coast and occurs inter-tidally on beaches and in deeper waters. In the first case, capelin literally "roll" on sandy or fine gravel beaches. Spawning essentially occurs at water temperatures of 6-10°C and is more predominant at night. The eggs, which are reddish in colour and approximately 1 mm in diameter, attach to the substrate. The incubation period varies according to ambient temperature, lasting for approximately 15 days at 10°C. Upon hatching, larvae quickly adopt a planktonic existence and remain near the surface until the arrival of winter. The most significant growth period occurs during the first year. Males are longer than females, with maximum lengths rarely above 210 mm. Capelin can spawn at 2 years of age, and nearly 100% of males die following reproduction.

Capelin represent a very significant link in the food chain as they allow the transfer of energy from primary and secondary producers to higher trophic levels. In the mid-1980s, the annual capelin consumption by its main predators was approximately one million tons. In the early 2000s, despite a sharp drop in cod (*Gadus morhua*) and redfish (*Sebastes* spp.) abundance, nearly 400,000 t of capelin were still consumed by predators (C. Savenkoff, DFO, Mont-Joli, pers. comm.), making this small fish the principal forage species of the northern Gulf of St. Lawrence marine ecosystem over the last 20 years.

ANALYSIS

Commercial Fishery

Description of fishing activities

Capelin fishing seasons are generally short and correspond to the pre-spawning period for the seine fishery and to the spawning period for the trap and weir fisheries. In the case of the purse seine and trap, the fishery mostly targets mature females for the Japanese roe market. The emergence of this market in the late 1970s is responsible for the sharp increase in landings, up from an average of 700 t/year between 1960 and 1976 to approximately 10,000 t in 1978 and 1979, and in 1992, 1993, 1998, and 2005 (Figure 2). Landings exceeding 10,000 t were even made in 2006 and between 2008 and 2011. Since 2005, a 13,000 t TAC was established and associated with the Estuary and Gulf of St. Lawrence. The distribution of the TAC is 11,195 t for Division 4R and 1,805 t for Divisions 4ST.

Most capelin catches in the Estuary and Gulf of St. Lawrence are from the west coast of Newfoundland, i.e. in NAFO Division 4R (Figure 1). In Divisions 4R and 4S, the most intensive fishing is usually made in June and July. In unit area 4Tp (Estuary), the fishing season can begin as early as April, but most catches occur in May and June. The fishing activities in this unit area have greatly decreased over the years.

Since the end of the 2000s, unit area 4Tn (Figure 1) is the subject of a more sustained purse seine fishery. From 2009 to 2011, annual landings from this fishery totalled 1,367 t, 1,258 t, and 1,409 t.

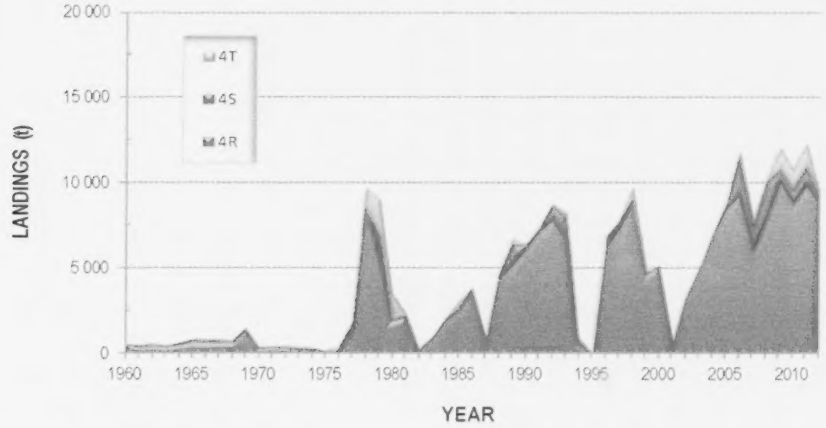


Figure 2. Capelin landings (t) in NAFO Divisions 4RST, from 1960 to 2012. Since 2005, the TAC of 13,000 t associated to the Estuary and Gulf of St. Lawrence has been divided as follows: 11,195 t for Division 4R and 1,805 t for Divisions 4ST.

2008-2012 fishing seasons

Since 2008, annual landings in Division 4R totalled between 7,846 t and 10,147 t (Table 1), which represent 70-91% of the portion of the TAC allocated to this division (11,195 t). For the same period, landings in Division 4S have varied from 478 t to 2,126 t and from 99 t to 1,449 t in Division 4T.

The three main fishing gears exploiting commercially capelin are purse seine, "Tuck ring" seine and trap (Table 1, Figure 3). In 2012, landings associated to these fishing gears were 6,374 t, 2,287 t, and 684 t, respectively.

In 2012, most of the landings in Division 4R were made in unit area 4Rc with a total of 5,558 t (Table 2). In Divisions 4S and 4T, the main landings were made in unit areas 4Sw (Quebec Lower North Shore) and 4Tn (Miscou Bank). The decrease in the trap landings in 4Sw in 2012 would have been caused by a spawning carried out offshore (4Sw traps being near the shore) and in deep water. As for the decrease in the landings in 4Tn in 2012, it would be explained by an earlier spawning which would have resulted in the absence of significant quantities of capelin by the time of the arrival of the seiners on the fishing grounds.

Table 1. Estuary and Gulf of St. Lawrence capelin landings (t) by NAFO Division and fishing gear for the 1985-2012 period.

DIVISION / GEAR	AVERAGE		YEAR													AVERAGE
	1985-1989	1990-1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*	2000-2011
4R	3 369	5 563	5 129	741	3 295	5 032	6 975	8 522	9 326	6 065	7 846	10 147	8 769	9 890	6 847	6 813
4S	241	350	0	0	77	0	0	305	2 039	1 344	2 126	527	795	974	478	682
4T	306	237	0	0	20	0	0	34	518	471	99	1 405	1 258	1 449	147	438
"Tuck ring" seine	0	0	0	0	0	0	0	182	788	519	967	1 657	1 558	1 271	2 287	579
Purse seine	2 586	4 872	5 129	741	3 295	4 654	4 639	5 485	7 335	5 097	6 916	7 445	7 197	7 760	6 374	5 474
Other seine**	88	59	0	0	0	0	188	116	193	133	54	141	0	93	127	76
Trap	960	1 040	1	0	7	379	2 148	3 078	3 567	2 151	2 135	2 837	2 067	3 189	664	1 797
Weir	243	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trawl	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Other	39	89	0	0	87	0	0	0	0	0	0	196	234	0	0	43
TOTAL	3 916	6 151	5 129	741	3 392	5 032	6 975	8 861	11 883	7 900	10 071	12 276	11 056	12 314	9 472	7 969

* Préliminary ** Not specified

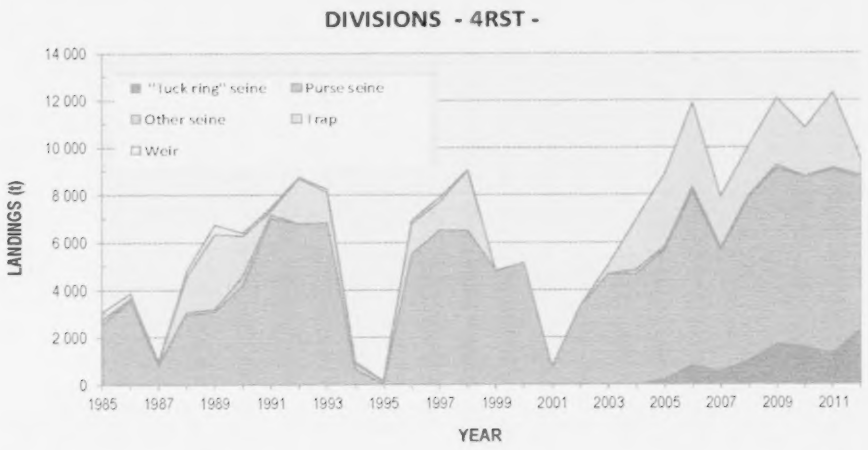


Figure 3. Capelin landings (t) in the Estuary and Gulf of St. Lawrence by fishing gear for the 1985-2012 period.

Table 2. West coast of Newfoundland (4R) capelin landings (t) by NAFO unit area for the 1985-2012 period.

UNIT AREA	AVERAGE		YEAR													AVERAGE
	1985-1989	1990-1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*	2000-2011
4Ra	1 163	699	0	0	115	513	3 965	4 948	5 917	5 315	883	2 570	2 409	3 378	1 418	2 501
4Rb	41	1 261	356	0	856	1 070	765	942	9	6	188	2 929	4 785	507	1 652	1 034
4Rc	439	2 812	4 773	605	2 323	3 450	2 185	2 289	2 644	691	2 692	4 116	1 442	4 021	5 558	2 603
4Rd	52	527	0	136	0	0	61	346	756	73	4 083	531	133	1 985	179	675
NK**	1 673	264	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3 369	5 563	5 129	741	3 295	5 032	6 975	8 522	9 326	6 085	7 846	10 147	8 769	9 890	8 847	

* Preliminary, ** Not specified

Location of catches and purse seine fishery performance

Purse seine fishing activities on the west coast of Newfoundland can be concentrated in some locations only. In 2010, capelin catches were made mostly to the south of Port au Choix (4Rb) and in Port-au-Port Bay (4Rc) (Figure 4). In 2011, the main fishing zones extended from Cap St-Gregory (4Rc) to Port-au-Port Bay and included the southern end of St-George's Bay (4Rd). Finally, in 2012, the fishing activities occurred mainly in Port-au-Port Bay.

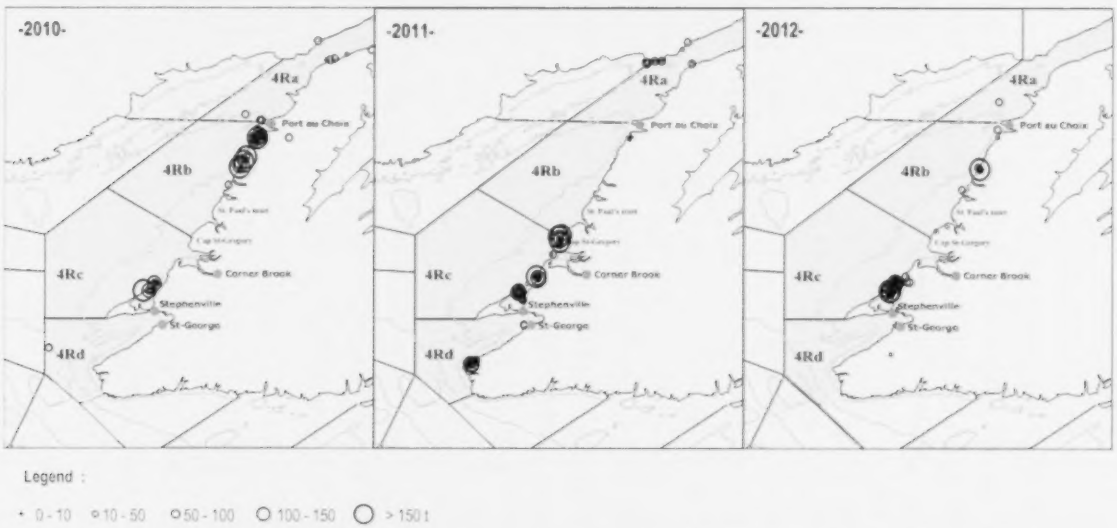


Figure 4. Locations of capelin catches (t) made by the commercial purse seine fishery in NAFO Division 4R, from 2010 to 2012.

The performance of the purse seine fishery in Division 4R is measured using a standardized index of the catch-per-unit-effort (t/day). This index is on the rise since 2005 and the values since the last years are the highest of the series (Figure 5). The average index of the 1986-2011 period is 46 t per fishing day. The upper limit (average + 0.5 × standard deviation) is exceeded since 2008. The index presents a non-significant decline between 2011 and 2012.

A performance index of the fishery was also calculated from the capelin catches made by purse seine in the southern Gulf of St. Lawrence (4Tn). However, no significant difference was measured between the annual values.

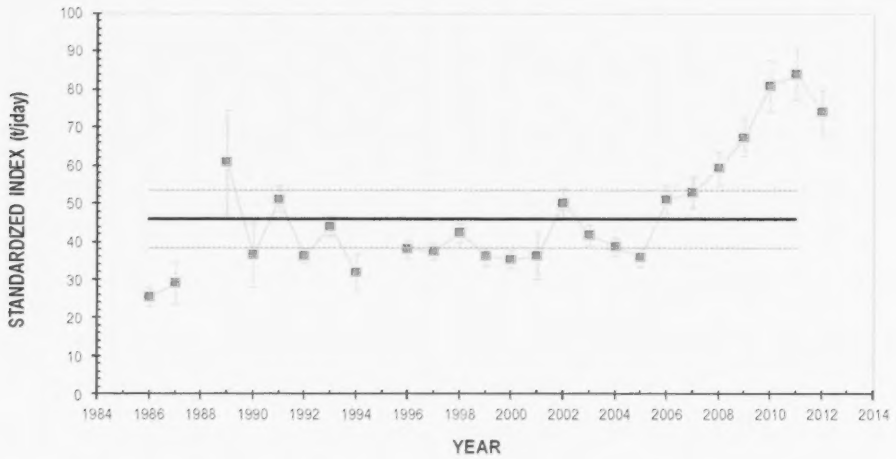


Figure 5. Performances (t/day) of the purse seine fishery in NAFO Division 4R (west coast of Newfoundland) as calculated by a catch-per-unit-effort standardized index (vertical bars represent standard errors). The horizontal solid line represents the average of the 1986-2011 period and the dotted lines represent the average ± 0.5 × standard deviation.

Shrimpers by-catches

Capelin is a regular by-catch in the shrimp fishery. In the spring, and in areas such as the Esquiman Channel or west of Anticosti Island, the number of capelin caught by shrimpers can be significant. Fishermen sometimes prefer to avoid some sectors during certain periods to avoid catching too many capelin. According to observers' data, capelin by-catches by shrimpers were 149 t in 2012. Since 2000, these by-catches have varied from 77 t to 322 t (Figure 6). Most of these catches were made in the Seven Islands and Esquiman shrimp fishery areas.

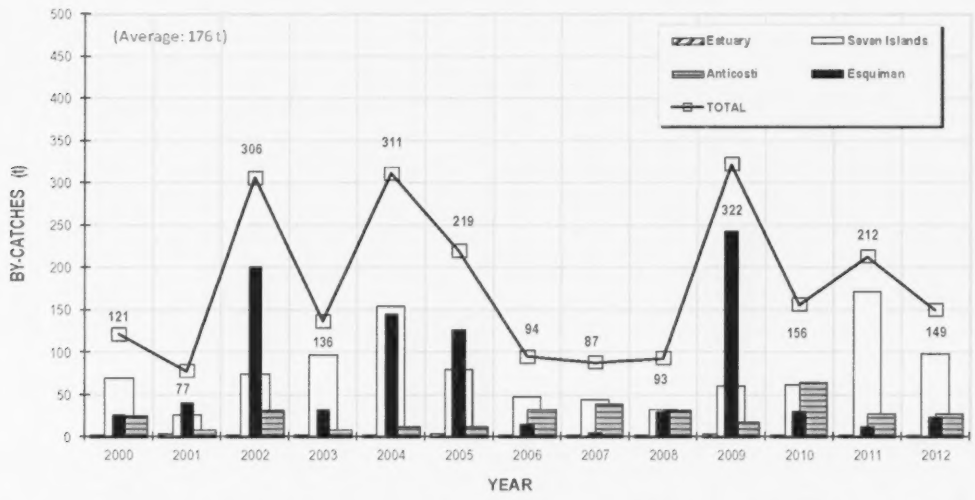


Figure 6. Annual capelin by-catch (t) estimated from the commercial shrimp fishery since 2000 (source of data: L. Savard, DFO, Mont-Joli, pers. comm.).

Description of catches

On the west coast of Newfoundland, mean lengths for both female and male capelin caught by seine decreased between 1986 and 1993 (Figures 7A and 7B). As the fishing effort is dependent upon fish size, the fishery at this location was cut short in 1994, and almost completely closed in 1995. Capelin size stabilized between 1996 and 1998 before decreasing again in 1999. Lengths increased until 2005 and then fluctuated around the average without showing clear trend. In 2012, the mean length was 149 mm for females and 163 mm for males compared to respective averages (1984-2011) of 147 mm and 165 mm.

Over the years, mean lengths for capelin on the east coast of Newfoundland (Divisions 3K and 3L) show the same annual variations as on the west coast (Figures 7A and 7B). However, lengths measured on the east coast were greater during the 1980s. This decline in the mean length would have been caused by a reduction of the age structure.

Fluctuations in capelin size are also observed in the annual length frequencies (Figures 8A and 8B). In most cases, length frequencies present only one mode as a result of overlapping lengths among various age groups.

The lengths of capelin female (Figure 9A) and males (Figure 9B) caught by seine are similar or slightly larger in 4R compared to unit area 4Sw. However, the lengths of capelin caught in these two sectors are greater than those measured in unit area 4Tn.

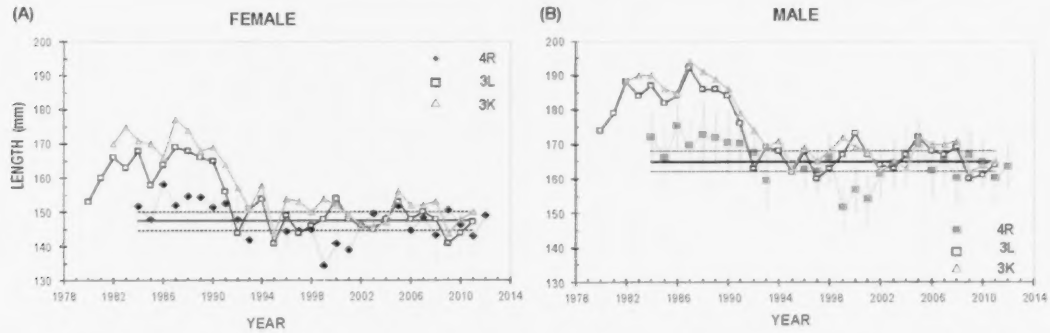


Figure 7. Mean lengths (mm) of female (A) and male (B) capelin caught with seines (purse and "Tuck ring") in NAFO Division 4R since 1984. Mean lengths for the east coast of Newfoundland (Divisions 3L and 3K) are also presented (Dr. B. Nakashima, DFO, St. John's, pers. comm.). Error bars represent the standard deviations. The horizontal solid lines indicate the averages (4R) of the 1984-2011 period and the dotted lines the average ± 0.5 × standard deviations.

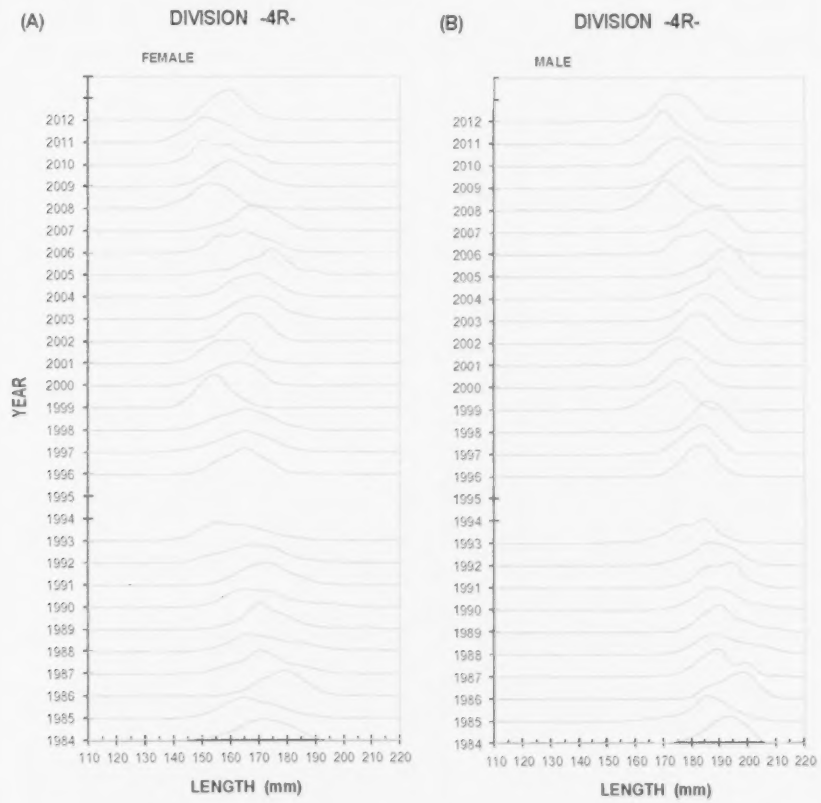


Figure 8. Length (mm) frequencies (%) of female (A) and male (B) capelin caught with seines (purse and "Tuck ring") in NAFO Division 4R between 1984 and 2012.

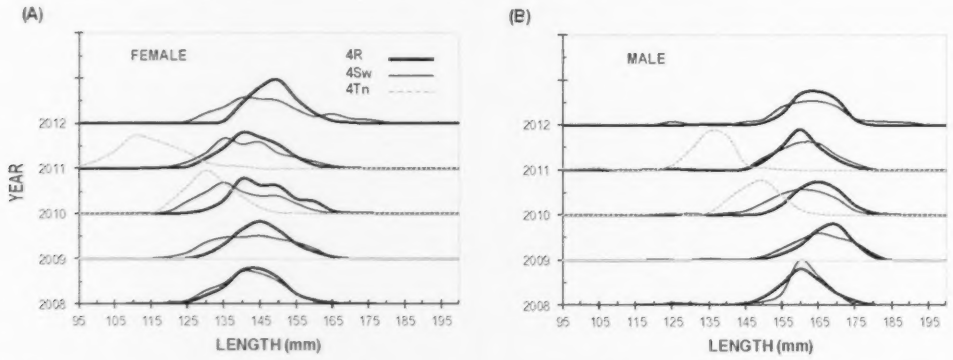


Figure 9. Length (mm) frequencies (%) of female (A) and male (B) capelin measured since 2008 from samples of the seine fishery (purse and "Tuck ring") in Division 4R (west coast of Newfoundland) and unit area 4Tn (southern Gulf of St. Lawrence) and from the trap fishery in unit area 4Sw (Quebec Lower North Shore).

Resource status

Catch distribution and dispersion index

Capelin are a regular catch in the DFO groundfish and shrimp multidisciplinary surveys conducted in the Estuary and Gulf of St. Lawrence. A dispersion index (and not of abundance) was calculated by indicator kriging based on the catches (presence and absence) made during these surveys. This index indicates a clear upward trend since 1990 for the Estuary and Gulf of St. Lawrence (Figure 10). Since 2010, the index values are the highest of the series. The review of the indices for each division reveals the presence of fluctuations on the west coast of Newfoundland (Division 4R) and upward trends in the northern Gulf (Division 4S), and more significantly, in the southern Gulf (Division 4T) (Figure 11). During these surveys, the highest probabilities (80-100%) of catching capelin were found in the Estuary, in the Anticosti area, and in the southern Gulf, between the Magdalen Islands and Prince Edward Island (Figure 12).

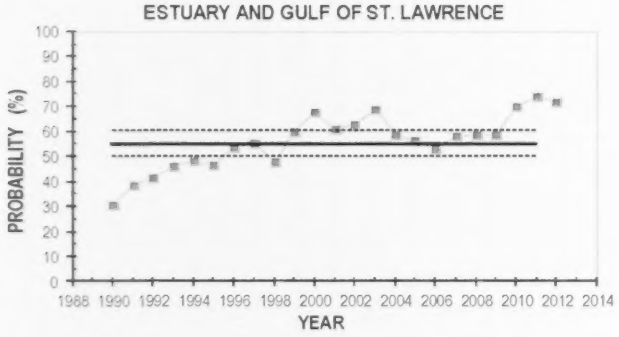


Figure 10. Capelin dispersion index (%) for NAFO Divisions 4RST covered by the groundfish and shrimp multidisciplinary surveys in the Estuary and northern and southern Gulf of St. Lawrence. The horizontal solid line indicates the average of the 1990-2011 period and the dotted lines the average ± 0.5 × standard deviation. Estuary and northern Gulf surveys are conducted in August and surveys in the southern Gulf, in September.

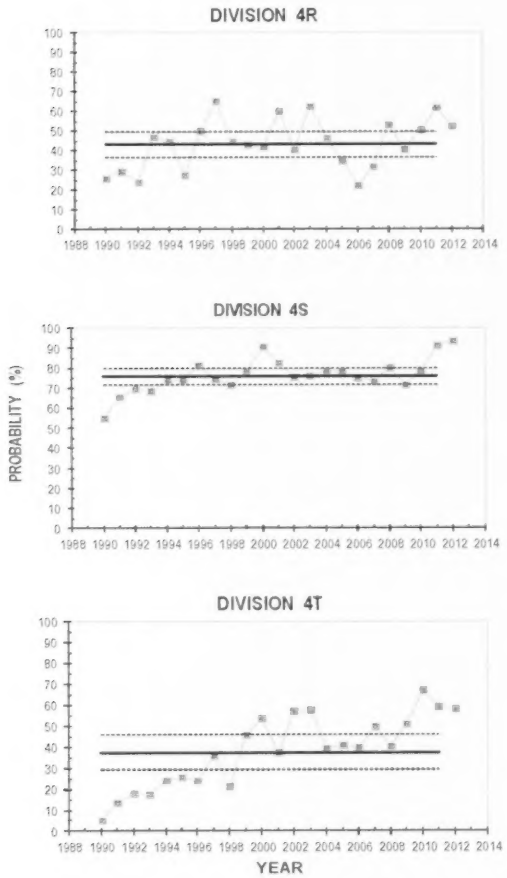


Figure 11. Capelin dispersion indices (%) for the NAFO Divisions covered by the groundfish and shrimp multidisciplinary surveys in the Estuary and northern and southern Gulf of St. Lawrence. The horizontal solid lines indicate the averages of the 1990-2011 period and the dotted lines the averages ± 0.5 × standard deviations.

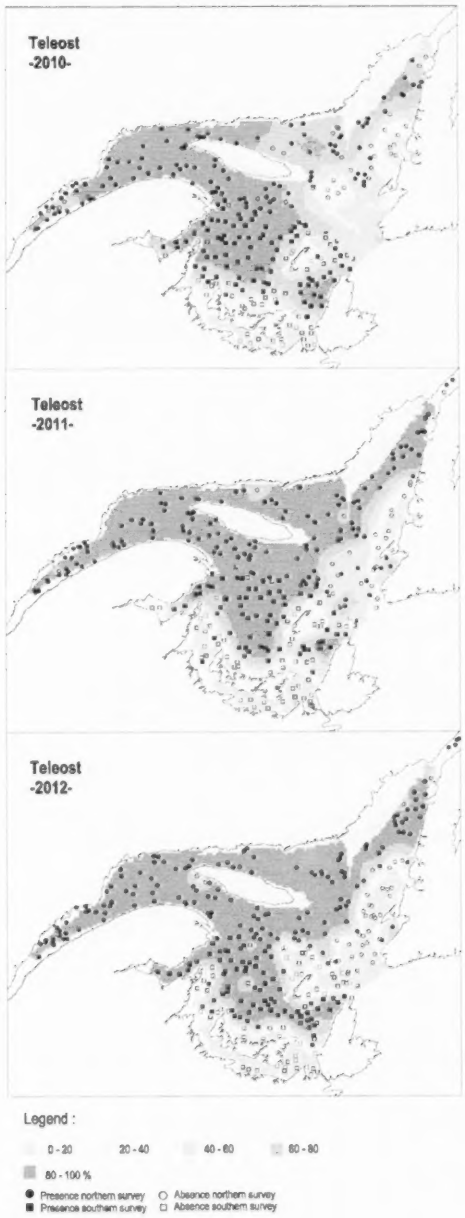


Figure 12. Surface probability (%) maps of capelin occurrence in the Estuary and Gulf of St. Lawrence as measured in 2010, 2011, and 2012 by the groundfish and shrimp multidisciplinary surveys. Station location, capelin occurrence and the 100 m isobath are indicated.

Capelin in the southern Gulf of St. Lawrence

Capelin catches from the groundfish multidisciplinary survey in the southern Gulf of St. Lawrence have increased significantly since 1990, being almost nil prior. The first significant catches were made offshore Gaspé in 1991, and gradually extended southward in following years. Since 2010, capelin are found in almost all bottom trawl tows (Figure 13).

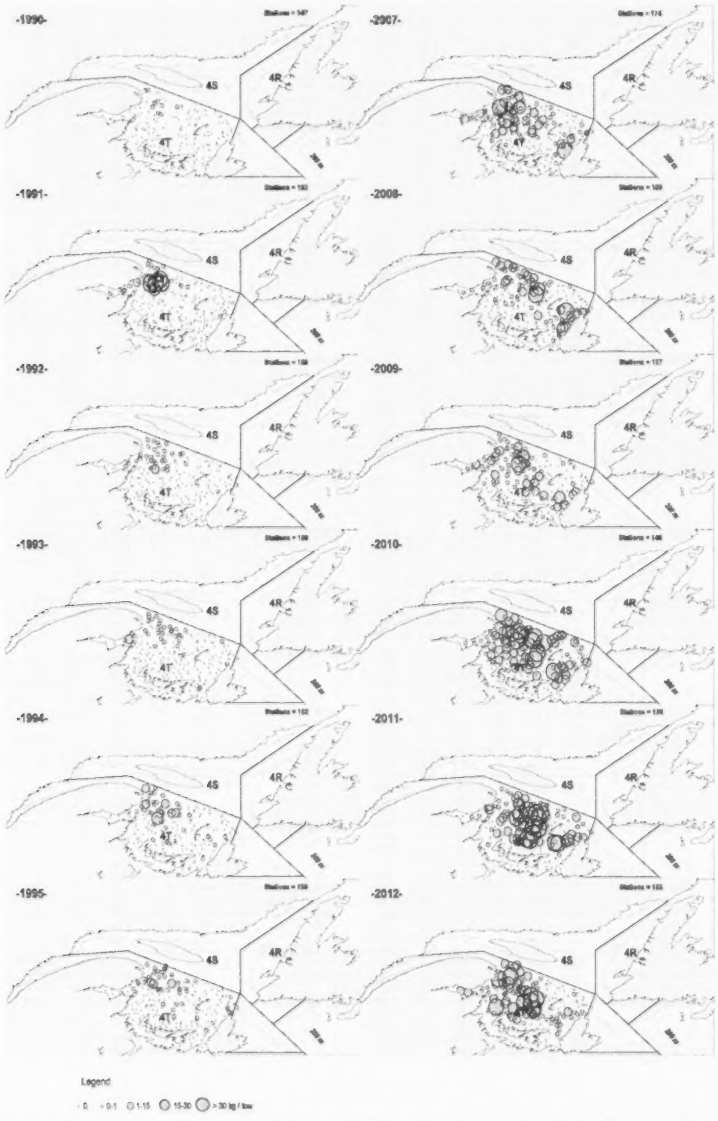


Figure 13. Weight (kg) per tow by the groundfish multidisciplinary survey in the southern Gulf of St. Lawrence for the 1990-1995 and 2007-2012 periods (T. Surette, DFO, Moncton, pers. comm.).

This increase could be explained by an increased presence of capelin near the bottom and/or by a change in abundance and/or dispersion.

Sources of uncertainty

The primary source of uncertainty is the absence of information regarding the real size of the Estuary and Gulf of St. Lawrence capelin stock because we do not have an index of the stock abundance. There is also a lack of information on the number, the location, and size of spawning grounds and stock structure. Furthermore, there is very little information concerning the role of certain environmental variables on annual migration patterns.

Ecosystem

Marine ecosystem models indicate that capelin was the primary prey for the northern Gulf of St. Lawrence ecosystem and represented on average 50% of the consumed matter in the ecosystem, between the mid-1980s and mid-2000s. Therefore, the main cause of capelin mortality is predation (Figure 14), mostly by large cod and redfish during the mid-1980s, by cetaceans, harp seals (*Phoca groenlandica*) and small Greenland halibut (*Reinhardtius hippoglossoides*) during the mid-1990s and the early 2000s, and by redfish and capelin during the mid-2000s (Figure 15) (C. Savenkoff, DFO, Mont-Joli, pers. comm.). Fishing mortality does not appear to have a noticeable effect on the population(s) at current landing levels, although this is currently impossible to evaluate given the absence of an acoustic survey conducted specially on capelin.

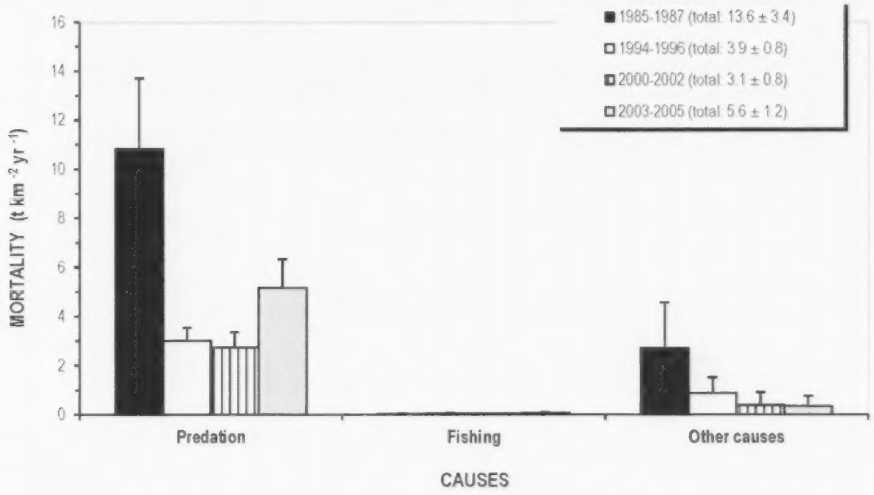


Figure 14. Main causes of capelin mortality (t km^{-2} yr^{-1}) according to different northern Gulf of St. Lawrence marine ecosystem models (Divisions 4RS) from the mid-1980s to the mid-2000s.

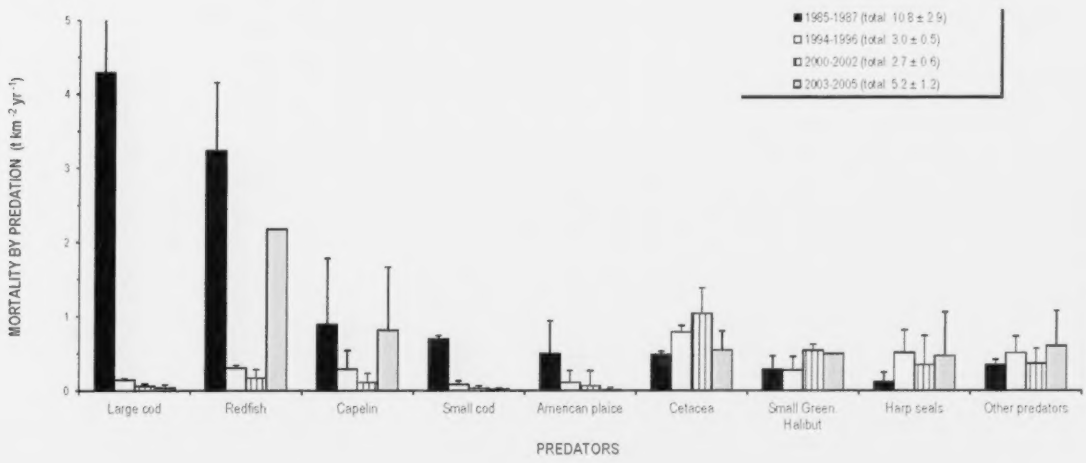


Figure 15. Detailed mortality by predation according to different northern Gulf of St. Lawrence marine ecosystem models (Divisions 4RS) from the mid-1980s to the mid-2000s.

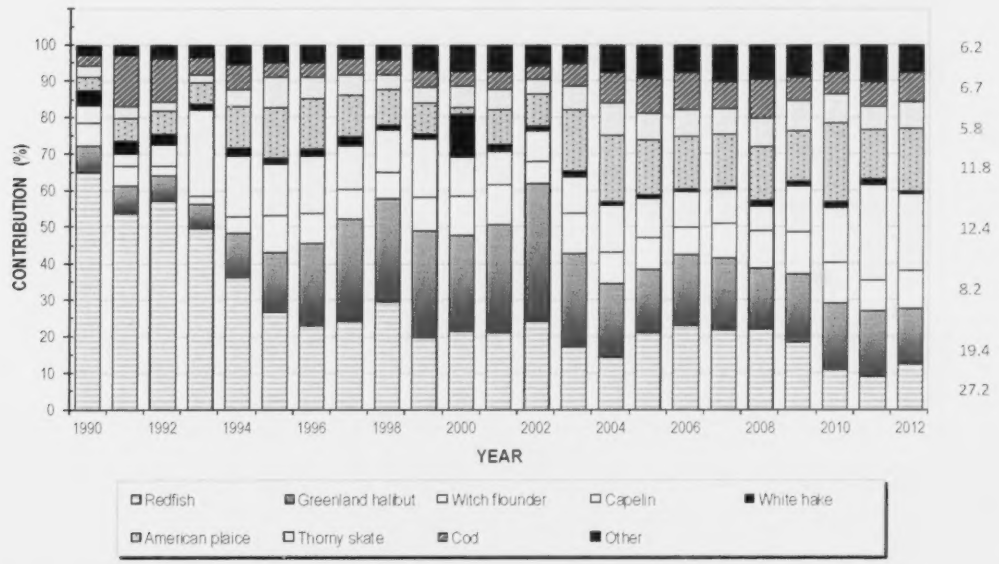


Figure 16. Contribution (%) of capelin catches and its main predators to groups of species that characterized the groundfish multidisciplinary surveys conducted in the northern Gulf of St. Lawrence between 1990 and 2012. The global average contributions, in percentage, are also shown for this period.

Capelin is among the main species characterizing the catches of the groundfish and shrimp multidisciplinary surveys in the northern Gulf of St. Lawrence (Figure 16). Its average contribution to the multidisciplinary surveys for the 1990-2012 period is 12.4% compared to 27.2% for redfish, 19.4% for turbot, and 11.8% for American plaice (*Hippoglossoides platessoides*). During these surveys, capelin catches are associated with those of its main predators according to their abundance and distribution so, in recent years, this association was more related to the Greenland halibut and American plaice than to redfish and cod.

CONCLUSION AND ADVICE

Summary of the assessment

The main indicators of the fishery and stock status of the Estuary and Gulf of St. Lawrence capelin are the commercial landings, the mean lengths of females and males, the index of performance (t/day) of the purse seine fishery and the dispersion index from the groundfish and shrimp multidisciplinary surveys. Compared to the 2001 season, the decrease in landings in 2012 was especially marked in Divisions 4S and 4T. According to the industry, higher water temperatures would have caused an earlier spawning in 4Tn and a spawning that would have occurred offshore and in deeper water in 4Sw. These two events would have reduced the capelin availability to the fishing gears. Lengths of females and males didn't present any alarming signs in 2012 and are in the historical averages. The performance index of the 4R fishery decreased in 2012 but this decline is not significant when variability measures are taken into account. This index has even reached historical highs since 2010. The dispersion index for the entire Gulf has been on the rise since the beginning of the 1990s to reach historical highs. However, annual fluctuations of this index characterize the west coast of Newfoundland.

Recommendations

It is currently impossible to estimate the impact of a significant increase in landings on the capelin population(s) and the rest of the ecosystem because variations in capelin abundance are first and foremost the result of natural factors. As capelin has a short lifespan, its abundance can be subject to large changes as a population consists of only a few age groups. To satisfy market demand, fishing effort is strongly correlated to the size of female capelin. The industry has a greater interest in regions where environmental conditions are more favourable to capelin growth. Although the commercial fishery may harvest a very small proportion of the total biomass, any TAC increase should be made cautiously due to capelin's prominent role as a forage species in the marine ecosystem.

According to the results of this assessment, any increase in the 4RST TAC should be made cautiously, less than 10% as a total over the next two years. The fishing effort should be more dispersed along the coast and less concentrated locally.

SOURCES OF INFORMATION

This Science Advisory Report presents the results of the meeting held on February 23, 2013 for the "Assessment of the Estuary and Gulf of St. Lawrence (Divisions 4RST) Capelin Stock in 2012". Additional publications from this meeting will be posted as they become available on the DFO Science Advisory Schedule.

Grégoire, F., Bourdages, H., and Ouellet, J.-F. 2012. Analyses of the capelin (*Mallotus villosus*) abundances from the multidisciplinary groundfish and shrimp surveys conducted in the Estuary and northern Gulf of St. Lawrence from 1990 to 2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/022. vi + 94 p.

McQuinn, I. H. 2009. Pelagic fish outburst or suprabenthic habitat occupation: legacy of the Atlantic cod (*Gadus morhua*) collapse in eastern Canada. Can. J. Fish. Aquat. Sci. 66: 2256-2262.

Savenkoff, C., Grégoire, F., and Chabot, D. 2004. Main prey and predators of capelin (*Mallotus villosus*) in the northern and southern Gulf of St. Lawrence during the mid-1980s and mid-1990s. Can. Tech. Rep. Fish. Aquat. Sci. 2551: vi + 30 p.

THIS REPORT IS AVAILABLE FROM:

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ISSN 1919-5087
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Correct Citation for this Publication:

MPO. 2013. Assessment of the Estuary and Gulf of St. Lawrence (Divisions 4RST) Capelin Stock in 2012. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2013/021.

Aussi disponible en français :

MPO. 2013. Évaluation du stock de capelan de l'estuaire et du golfe du Saint-Laurent (Divisions 4RST) en 2012. Secr. can. de consult. sci. du MPO, Avis sci. 2013/021.